The treatment of non-vital immature permanent teeth by filling of root canals with calcium hydroxide

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SUMMARY. Aim The aim of the present clinical study was to evaluate the endodontic method of treatment consisting of gentle preparation of the root canal and subsequent temporary filling with calcium hydroxide. The filling of the root canal with calcium hydroxide was repeated approximately at three-month intervals.

Method The study consisted of a test group of 98 children with 103 non-vital single-root permanent immature teeth, 56 (54.4%) at developmental stage II and 47 (45.6%) at stage III. A control group consisted of 193 non-vital teeth treated by a periapical-surgical method. Treatment consisted of access cavity and instrumentation of the root canals, irrigation and dressing with non-setting calcium hydroxide proprietary paste. Dressings were replaced at 1-2 month and at 3 month intervals until an apical barrier formed. Root treatment was completed with gutta-percha and AH plus paste.

Results Of the 103 non-vital immature teeth the treatment was successful in 97 cases. In four cases the treatment could not be finished because of failure to attend. A failure of endodontic treatment occurred in two cases. Continued development of the root was found in three children, and in all remaining cases the hard tissue barrier closed or narrowed the apical opening. Statistically significant earlier completion of treatment was found in the teeth treated in the stage II of development compared with stage III.

Conclusion Endodontic treatment with calcium hydroxide is preferred over periapical surgical treatment for immature non-vital permanent teeth in children.

KEY WORDS. Non-vital immature permanent tooth, Calcium hydroxide

Introduction The treatment of non-vital immature permanent teeth is one of the least frequent but very important and often complicated tasks of paediatric dentistry. The selection of therapy is guided primarily by the stage of development of the tooth to be treated, the degree of infection of periapical tissues, the overall health condition of children and their capacity to co-operate during the treatment. The therapeutical procedures used should also take into account the orthodontic irregularities of teeth. For the purpose of this treatment, a tooth with incomplete development is considered to be a tooth in the period between its eruption and the closing of the apical foramen. The developmental period can be divided into four stages [Komínek et al., 1980].

Stage I: the tooth has a very short root consisting predominantly of a mesodermal papilla communicating widely with the surrounding tissues. Stage II: the root development has progressed to the stage in which the root walls are still rather thin and the root canal diverges towards the apical foramen. The ratio of the root length to the length of the clinical crown is 1 : 1 and later on 1.3-1.5 : 1. Stage III: the root has almost grown to its final length and the canal walls are calcifying. Stage IV: the root has reached its definitive length, and the canal walls are converging towards the apical foramen, but the extent of the pulp cavity in both the coronal and root parts of the tooth is greater than that found in the teeth of adults.

The treatment of teeth with non-vital pulps at stage I and in some cases at stage III and IV, can be considered manageable in view of the current knowledge and the technical advances of dentistry. However, problems are likely to arise when such teeth are treated at stages II and sometimes III, when the common endodontic approach is
inadequate and the periapical-surgical methods are not always successful, as they are rather stressful and require a high degree of cooperation from a child.

Various authors [Morse et al., 1990; Cvek, 1994; Sheehy and Roberts, 1997] recommend the endodontic methods of treatment even for teeth at developmental stage II. These methods consist either in narrowing the broad apical foramen or its closing by induced development of hard tissues. In exceptionally successful cases a further growth of the root has been observed. Both processes make it possible for a dentist to apply a definitive root canal filling having minimal contact with the periapical tissues. This filling can be made without surgical intervention.

A study was therefore carried out to compare the various approaches to the treatment of non-vital immature permanent teeth. This consisted of an endodontic method of treatment for teeth with non-vital pulps at developmental stage II and, in selected cases, stage III.

Materials and methods

The test group consisted of 98 children, 63 were boys (64.3%) and 35 girls (35.7%), who were undergoing treatment at the Department of Dentistry, Faculty of Medicine in Pilsen, between 1988 and 1998. No special selection of the patients was performed, but all children were included into the study. The tested group presented tooth treatment cases, 93 patients (94.9%) had one tooth treated, 5 patients (5.1%) two teeth each, comprising a total of 103 teeth.

The following data on group were collected:
1. the type of teeth treated;
2. the developmental stage of each tooth;
3. the cause of the tooth pulp loss vitality;
4. the time period between trauma and treatment;
5. the existence of a fistula and/or looseness of the tooth;
6. the presence of periapical lesion;
7. the age of the patient at the beginning of treatment;
8. the existence of a hard tissue barrier at the apical part of the root canal or development of the root;
9. the total time of treatment;
10. the long-term results after definitive root canal filling.

Teeth that were not included in the research program were those with extensive periapical lesions, i.e. radiographic lesions with size 200 mm² and larger or cases in which radiolucency involves periapical areas of more teeth. In these cases clinical diagnosis of a periapical cyst is reasonable. For this reason four teeth were excluded from the research program.

The endodontic method of treatment for permanent teeth with non-vital pulps, stages II and III, was that developed by Kilian and Zámyslick, [1976] alongside similar methods described in the literature and applied elsewhere. Our method consists of an ordinary endodontic preparation of the root canal and subsequent repeated filling with a proprietary calcium hydroxide filling, “CaIyx” (Spofa-Dental Comp., Czech Republic) containing calcium hydroxide and methyl cellulose.

Treatment. At the first visit a tooth with non-vital pulp was isolated with a rubber dam or cotton rolls and an aspirator was used. An access cavity was prepared on the palatal surface of each tooth. The palatal opening must be large enough to allow instrumentation of all of the pulp chamber. The necrotic pulp was removed and a periapical radiograph taken. The working length was established at 2 mm of the apex to protect vital periapical tissues. Cleaning of the canal walls was carried out using files. The preparation was carried out gently with frequent saline irrigation and 2% sodium hypochloride solution was used for disinfection and dissolution of any organic remnants in the root canal. The last irrigation was made with saline solution, because it does not irritate the periapical tissues. The root canal was dried with paper points and filled with non-setting calcium hydroxide paste. A lentulo spiral filler is suitable to carry the paste to the working length of the root canal. After root filling, a cotton wool pledget was used to gently compress the calcium hydroxide paste before sealing the access cavity with a glass-ionomer cement.

The first calcium hydroxide dressing was replaced after 1 or 2 months, and then again at 3 months intervals until a barrier had formed at the apex. The presence of the calcific barrier was initially investigated by use of a paper point. If the barrier was present, the root canal was then filled with gutta-percha and A H® plus paste (Dentsply, Germany) using the lateral condensation technique.

Evaluation. For evaluation of the measure of success in the treatment of non-vital immature permanent teeth, the following criteria were used.
No clinical symptoms of periodontal alterations (i.e. looseness, painful occlusion, fistulas).

A barrier of hard tissue, identifiable by radiographic examination or by clinical methods, narrowing down or fully closing the apical foramen, the continuing development of the root, proved by radiographs and the ability to fill the root canal with guttapercha without excess of filling material.

A significant decrease in the size of the periapical radiolucency (if any), identifiable from radiographs taken over the period of 6 to 12 months after beginning of treatment.

The relationship between the total time of treatment and developmental stages and diagnosis has been evaluated by the statistical method of analysis of variance (ANOVA).

The control group consisted of 193 non-vital immature teeth, that had been treated by periapical-surgical method [Komínek and Rozkovcová, 1968], with single-root permanent teeth at developmental stage II. All control teeth had been necrotic due to various kinds of injuries.

In the test group the most frequent type of teeth to be treated were maxillary central incisors: the right central incisors 44 cases (42.7%) and the left central incisors 35 cases (34%). Furthermore, there were five right lateral incisors (4.9%) and eight left lateral incisors (7.7%). Other types of teeth were quite rare: canines in two cases (1.9%), lower premolars in six (5.8%) and lower incisors in three cases (2.9%). Of the total 103 teeth, at the beginning of the treatment 56 (54.4%) were at developmental stage II, 47 (45.6%) at stage III.

**Results**

The age distribution in the groups was 9-10 years (24 children, 24.5%) and 8-9 years (21 children, 21.4%). The youngest patient who received treatment of root canal with calcium hydroxide was 6.7 years old, the oldest was 15 years of age (tooth 35). The age distribution curve for the whole group at the beginning of treatment is shown in Fig. 1. The identified causes of pulp necrosis were trauma or injury of the tooth in 88 cases (85.4%), malformation of the hard tooth tissues in 10 cases (9.7%) and deep caries in five cases (4.9%). The time period between trauma of 88 immature non-vital teeth and their treatment with calcium hydroxide is shown in Table I. The endodontic treatment was started in 20 teeth (22.7%) during the first month after trauma; 69 teeth (78.4%) were treated during the first year after trauma and 19 teeth (21.5%) between 12-36 months after injury. Fistulas and loose teeth were diagnosed in 21 (20.4%) and 19 (18.4%) cases, respectively. Both fistulas and looseness of teeth disappeared in all cases after two or three weeks of treatment. Periapical lesions had occurred in 58 teeth before endodontic treatment was started.

The results in the control group (193 immature teeth)

<table>
<thead>
<tr>
<th>Time period (months)</th>
<th>Number of teeth</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1</td>
<td>20</td>
<td>22.7</td>
</tr>
<tr>
<td>1-3</td>
<td>15</td>
<td>17.0</td>
</tr>
<tr>
<td>3-6</td>
<td>16</td>
<td>18.2</td>
</tr>
<tr>
<td>6-12</td>
<td>18</td>
<td>20.5</td>
</tr>
<tr>
<td>12-18</td>
<td>9</td>
<td>10.2</td>
</tr>
<tr>
<td>18-24</td>
<td>4</td>
<td>4.5</td>
</tr>
<tr>
<td>24-36</td>
<td>6</td>
<td>6.8</td>
</tr>
</tbody>
</table>

**Table I** - The time period between trauma and treatment using calcium hydroxide medicament in young permanent teeth

**Fig. 1** - Graph showing distribution of treated young permanent teeth by age and sex
TREATMENT OF NON-VITAL IMMATURE PERMANENT

non-vital permanent teeth) with the periapical-surgical treatment were that the treatment was successful in 91.2% cases (176 teeth) and the failure occurred in 9.8% (17 teeth).

Of the 103 non-vital immature permanent teeth the calcium hydroxide treatment in 97 cases (94.2%) was successful. In four cases (3.9%) the treatment could not be finished due to circumstances outside of our control as the children either moved or did not come when invited for the recall. A failure of the endodontic treatment occurred in two cases (1.9%). One of these was the case of a lower incisor with extensive osteitic lesion near the apex. Despite the repeated filling of the root canal, the apex would not close, and the treatment had to be completed surgically. The other unsuccessful case was a lower premolar with malformed hard tissues and pulp necrosis, with an osteitic lesion and an irregularly shaped root in which it proved impossible to fill the canal completely. During the final filling the child complained of severe pain. When the next therapy was inefficient, we had to extract the tooth after several days.

The continuing development of the root, i.e. its growth and continuing mineralization was shown only in three children (3.1%) (Fig. 2a and b). In all remaining cases radiographs showed the various types of the apex closure by a hard tissue or the narrowing of the broad apical foramen (Fig. 3a, b and c). Small overfilling of the root canal (i.e. over the apical foramen) during the definitive filling was found in seven teeth (7.1%). In all remaining cases the broad apical foramen was closed or narrowed to such extent that the root filling did not penetrate into the periapical tissues. The results for the various treatment modalities in length of treatment times are shown in Table II. The interval between the application of the first filling with calcium hydroxide and that of the definitive filling was shorter than three months in seven teeth (7.2%). It lasted from three to six months in 51 teeth (52%), from seven to ten months in 22 teeth (22.4%), and a period longer than ten months in 18 teeth (18.4%). In the test group 51 teeth (52.5%) with the definitive filling of the root canal were at stage II of development and 46 teeth (47.5%) at the stage III of development. In the group of 51 teeth of the stage II of development the definitive filling was applied after three to six months in 25 teeth (49%), after seven to ten months in 15 teeth (29.4%) and after a period longer than ten months in 11 teeth (21.6%). In the group of 46 teeth at the stage III of development we filled definitively root canals of seven teeth (15.2%) earlier than in three months, after three to six months of 26 teeth (56.5%), after seven to ten months of seven teeth (15.2%) and after a period longer than ten months of six teeth (13%).

The difference in the whole time of treatment between the teeth at the developmental stage II and stage III was statistically significant at level of 5%. The group of 97 teeth with successful treatment was divided into 31 teeth (32%) with pulp necrosis and 66 teeth (68%) with apical periodontitis and the whole time of treatment was investigated. The root canals of 31 teeth with pulp necrosis had been filled definitively earlier than in three months in four teeth (12.9%), after three to six months in 16 teeth (51.6%), after seven to ten months in nine teeth (29%) and after more than ten months in two teeth (6.5%).
The intervals between application of the first filling and definitive filling of the teeth with apical periodontitis were as follows: less than three months in three teeth (4.5%), after three to six months in 35 teeth (53%), after seven to ten months in 13 teeth (19.7%) and more than ten months in 15 teeth (22.7%). The difference in the whole time of treatment between the teeth with pulp necrosis and apical periodontitis was statistically significant at a level of 5%, i.e. the time of necessary treatment in the teeth with pulp necrosis was significantly shorter.

<table>
<thead>
<tr>
<th>Treatment stage</th>
<th>Number of teeth (%) - Time in months</th>
<th>&lt;3</th>
<th>3-6</th>
<th>7-10</th>
<th>&gt; 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interval of time between 1st application of Ca-OH &amp; RCT*</td>
<td>7 (7.2)</td>
<td>51 (52.0)</td>
<td>22 (22.4)</td>
<td>18 (18.4)</td>
<td></td>
</tr>
<tr>
<td>Teeth at developmental stage II</td>
<td>-</td>
<td>25 (49.0)</td>
<td>15 (29.4)</td>
<td>11 (21.6)</td>
<td></td>
</tr>
<tr>
<td>Teeth at developmental stage III</td>
<td>7 (15.2)</td>
<td>26 (56.5)</td>
<td>7 (15.2)</td>
<td>6 (13.0)</td>
<td></td>
</tr>
<tr>
<td>Teeth with pulpal necrosis</td>
<td>4 (12.9)</td>
<td>16 (51.6)</td>
<td>9 (29.0)</td>
<td>2 (6.5)</td>
<td></td>
</tr>
<tr>
<td>Teeth with apical periodontitis</td>
<td>3 (4.5)</td>
<td>35 (53.0)</td>
<td>13 (19.7)</td>
<td>15 (22.7)</td>
<td></td>
</tr>
</tbody>
</table>

* = calcium hydroxide and definitive root canal treatment

**Table II**. The interval between the first application of calcium hydroxide and the definitive root filling.
The method of treatment for immature permanent teeth by filling the root canal with calcium hydroxide described above has proved very efficient in cases of teeth with non-vital pulps and periapical lesions of a lesser extent. So far the treatment has been confined to single-root teeth, although in the literature [Van Hassel and Natkin, 1970] successful application of this method to immature molars with non-vital pulps has been mentioned.

The closure of the root canal by induced development of hard tissues usually occurs even with teeth with malformation of the type dens in dente, where spontaneous necrosis of the pulp may occur before the root development has been completed [Suchina et al., 1989]. We have treated successfully 10 teeth of this type.

Saad [Cvek, 1974; Saad, 1991] also recommends calcium hydroxide for the temporary filling of the root canals of teeth with fractures in the middle and the apical third of the root. In our group of paediatric patients there were two cases of root fractures in which the method of repeated filling of the root canals with calcium hydroxide proved successful.

Calcium hydroxide is also considered the best filling material for reimplanted teeth [Trope, 1997]. Among the teeth treated in our department, there were four reimplanted teeth in which the application of calcium hydroxide filling was successful.

The method of repeated filling of the root canals with calcium hydroxide is also applicable to the teeth with internal root resorption, in cases of root perforation occurring during the endodontic treatment of the root canals or in teeth with external root resorption in which the wide apical orifice developed pathologically, even with fully developed teeth [Stock, 1985]. However, our experience with treatment of such teeth is limited. In our sample group there was only one tooth with external root resorption originating after the former intrusive luxation.

The method of repeated filling of root canals with calcium hydroxide is contraindicated for the teeth with radicular cyst and in cases with a risk of focal infection. The periapical-surgical treatment is more suitable for children with danger of focal infection. This treatment reduces a possibility of bacteria survival in the periapical area. Immature teeth with extensive periapical lesions require

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**Table III** - The long term results after the definitive root canal filling with calcium hydroxide in young permanent teeth

<table>
<thead>
<tr>
<th>Years after def. root filling</th>
<th>Number of teeth</th>
<th>No apical pathol.</th>
<th>Apical pathol.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>47 (48.5%)</td>
<td>39 (83%)</td>
<td>8 (17%)</td>
</tr>
<tr>
<td>2</td>
<td>8 (8.2%)</td>
<td>6 (75%)</td>
<td>2 (25%)</td>
</tr>
<tr>
<td>3</td>
<td>9 (9.3%)</td>
<td>9 (100%)</td>
<td>-</td>
</tr>
<tr>
<td>4 and more</td>
<td>33 (34.0%)</td>
<td>31 (94%)</td>
<td>2 (6%)</td>
</tr>
</tbody>
</table>

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**Discussion**

For its beneficial effect on periapical tissues, calcium hydroxide appears to be especially suitable for the temporary filling of root canals of the non-vital immature teeth. Some authors [Mackie et al., 1988, Morse et al., 1990] report on the application into the root canal of a paste consisting of calcium hydroxide in combination with camphorated monochlorphenol, camphor parachlorphenol, propylene glycol, metacresol acetate, or a radiopaque substance. Except for tricalcium phosphate, these materials have been used as a stop against which a gutta-percha root filling can be packed [Morse et al., 1990]. In our department the only material for temporary filling of the root canals is calcium hydroxide with methyl cellulose. X-ray contrasting substances are not used as they are considered risky in view of their possible unfavourable effects on periapical tissues and on the development of an apical barrier.

It is generally recommended to fill the root canal with calcium hydroxide at least twice within a period of two to three months. Mackie et al. [1988] achieved apical closure 7-8 months from beginning of the treatment. In our study we performed the final filling after 3 to 6 months with 52% of the treated teeth. We have found, however, that the total treatment time depends very much on the developmental stage of the treated tooth and on the status of the pulp and the periodontium.

The method of treatment for immature permanent teeth by filling the root canal with calcium hydroxide described above has proved very efficient in cases of teeth with non-vital pulps and periapical lesions of a lesser extent. So far the treatment has been confined to single-root teeth, although in the literature [Van Hassel and Natkin, 1970] successful application of this method to immature molars with non-vital pulps has been mentioned.

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The method of repeated filling of root canals with calcium hydroxide is contraindicated for the teeth with radicular cyst and in cases with a risk of focal infection. The periapical-surgical treatment is more suitable for children with danger of focal infection. This treatment reduces a possibility of bacteria survival in the periapical area. Immature teeth with extensive periapical lesions require
careful consideration [Caliskan and Turkun, 1997]. The application of the method is also questionable in cases of patients with poor co-operation.

The final evaluation of the research program yielded 94.2% of success in the group of treated teeth. This result is in overall agreement with the results by other authors, working with larger patient groups. For example Mackie [Mackie et al., 1988] treated and monitored the results of the treatment in a group of 112 non-vital immature teeth and 96% success rate was achieved. Of the four failures, three were teeth that had been avulsed and replanted and the last tooth had been repositioned following severe displacement. Vojinovic [Vojinovic, 1981] treated 102 immature teeth with apical periodontitis. The criteria for success were as follows: the periapical lesion completely healed, the restoration of the periapical space at the apex and the apical closure. During the observation period of 6 months to 6 years after finishing of the treatment, only two teeth were found failing the above criteria.

In cases where the endodontic treatment is found insufficient, the treatment can be completed with the use of surgical intervention. In our research program we have used surgical measures in one single case.

Comparing the results of our endodontic treatment with calcium hydroxide and the periapical-surgical method [Komínek and Rozkovcová, 1968] we have found very similar data. Our endodontic treatment was successful in 97 cases (94.2%) of the 103 non-vital immature teeth. The periapical-surgical treatment reached success in 95%. However, the periapical-surgical treatment is not entirely satisfactory for the following reasons:

1. the surgical treatment could be physically and psychologically traumatic to the young patient;
2. the child is often unable to co-operate during surgical treatment;
3. the surgical treatment removes the Hertwig's root sheath and prevents the tooth's possibility of further root development;
4. the periapical tissue may not adapt to the wide and irregular surface of the root canal filling material.

For these reasons the endodontic therapy is currently preferred.

References